1924

ROYAL SOCIETY OF NEW SOUTH WALES.

SYDNEY.

IMPERIAL BUREAU OF MYCOLOGY
11 AUG 1924

PRESIDENTIAL ADDRESS

BY

R. H. CAMBAGE, F.L.S.

[Delivered to the Royal Society of New South Wales and broadcasted on May 7th, 1924.]

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET, SYDNEY.
Issued 16th June, 1924.

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By R. H. Cambage, F.L.S.

Delivered to the Royal Society of N.S.W. and broadcasted on May 7, 1924.*

The Society's efforts have again been rewarded by a successful year, and our roll of membership now stands at 375.

In addition to the papers read at the general monthly meetings, the following popular science lectures were given, namely:—"Some Wonders of the Australian Flora," by R. T. Baker; "Historical and Modern Practice of Quarantine," by J. H. L. Cumpston, M.D., D.P.H.; "Some Industrial Achievements of Organic Chemistry," by Acting-Professor G. Harker, D.Sc.; "Some Ancient Volcanoes of Australia," by Assist. Professor W. R. Browne, D.Sc.

Successful meetings were held throughout the Session by the Sections of Geology, Agriculture and Industry.

The Council has awarded the Clarke Memorial Medal to Mr. J. H. Maiden, I.S.O., F.R.S., F.L.S., in recognition of his highly meritorious contributions to the Botany of Australia, and particularly of his monumental work on the genus *Eucalyptus,* as well as his very eminent services in the advancement of natural science in Australia. No one has given more of his best efforts to Australian science

*This is the first occasion on which an Address has been broadcasted from a Scientific Society in Australia.—(Editors).

in general, or to this Society in particular, than Mr. Maiden.

It is a pleasure to record that the following members have been honoured during the year:—

Sir George Knibbs, Knight Bachelor.

Sir Hugh Denison, Knight Commander of the British Empire.

Mr. Charles Hedley, Honorary Fellow of the New Zealand Institute.

Sir George Knibbs has now been a member of this Society for forty-three years, and is still actively engaged upon scientific work.

Mr. Hedley has recently resigned the position of Keeper of the Collections at the Australian Museum, and accepted an appointment as Scientific Director of the Great Barrier Reef Committee, and he carries with him our very best wishes for the success of the important work about to be undertaken.

I desire to record the Society's great appreciation of the assistance rendered throughout the year by the Honorary Secretaries, Professor O. U. Vonwiller and Mr. G. A. Waterhouse, also the Honorary Treasurer, Professor H. G. Chapman, all of whom have contributed much towards making the session a success.

OBITUARY.

It is with regret I have to announce that during the year we have lost by death a Vice-Patron and seven ordinary members.

Sir Walter Edward Davidson, K.C.M.G., Governor of the State of New South Wales from February, 1918, and a Vice-Patron of this Society, died at Government House,

Sydney, on the 16th September, 1923, and was buried at South Head Cemetery. He was born at Valetta, Malta, on April 20, 1859, and was a son of the late James Davidson, of Killyleagh, County Down, Ireland. A scholar and exhibitioner of Christ's College, Cambridge, he entered the Ceylon Civil Service in 1880 as a writer, and remained there for nearly 20 years. He was secretary to the Ceylon Commission and to the Colonial and Indian Exhibition in 1886, and chairman of the municipal council and Mayor of Colombo in 1898, also Ceylon Commissioner at the Paris Exhibition in 1900. In 1901 he went to the Transvaal as assistant secretary to the Administrator, and the following year was made a C.M.G., and appointed Colonial Secretary. In 1904 he was appointed Governor of Seychelles Islands, and in October, 1912, his appointment as Governor of Newfoundland was announced. He was a Knight of Grace of St. John of Jerusalem, and was created K.C.M.G. in 1914.

Sir Walter Davidson had been twice married. He was first married in 1882 to a daughter of the late Dr. John Baber, of Thurlow-square, London, and there was one son of the marriage. His second marriage took place in 1907, to Margaret Agnes, youngest daughter of the late General the Hon. Sir Percy Fielding, and there are two daughters of that marriage. Sir Walter Davidson wrote two books on Ceylon and its resources; in 1886 he wrote a book for the Colonial and Indian Exhibition, and in 1900 he wrote one for the Paris Exhibition. In 1909 he published a volume of "Archives of Seychelles prior to 1810."

Having a large grasp of public questions in their broadest aspects, Sir Walter Davidson was able to handle difficult problems connected with his duties, with a high degree of success, and being possessed of a sympathetic

nature, as well as a strict sense of justice, he soon won popularity as Governor of this State, and by getting into touch with all sections of the community, he endeared himself in a remarkable degree to the people of New South Wales.

Sir Walter Davidson was much interested in the work of science. He attended and spoke in an appreciative manner at the meeting of this Society held on 7th December, 1921, which was specially devoted to commemorating the formation, in 1821, of the Philosophical Society of Australasia, the first scientific Society in Australia, and the forerunner of the Royal Society of New South Wales.

He opened the Sydney session of the Pan-Pacific Science Congress on the 24th August, 1923, and delivered an inspiring address. He also provided a welcome for the visiting scientists by a Reception at Government House, and his last public act was to preside over Professor H. E. Gregory's lecture at the Town Hall, when the state of his health might well have furnished just cause for his deciding not to be present.

Henry Deane was born at Clapham, London, on 26th March, 1847, and was educated at Queen's College, Galway, and King's College, London, obtaining his M.A. degree at Queen's University of Ireland, and Sydney (*ad eundem*). He was first engaged in connection with the London metropolitan railways, and later was employed in Hungary and in the Philippine Islands on similar work. Coming to Australia, he joined the New South Wales Railway Construction Department in February, 1880, and eventually rose to the position of Engineer-in-Chief, in which capacity he was associated with many important engineering works, including the Hawkesbury River Bridge

and the introduction of tramways. He was twice sent abroad from the New South Wales service to report on the latest engineering developments.

In 1906 Mr. Deane retired from the service of this State, and accepted an appointment with the Commonwealth Oil Corporation, taking charge of the construction of the railway from the main western line on the Blue Mountains at Newnes Junction to the Wolgan River, where the oil-shale mine was then being established at Newnes. He introduced special engines, called "Shay locomotives," capable of negotiating the exceedingly steep grades and sharp curves on portion of this line. In 1908, Mr. Deane, who had previously been associated with the proposed East-West railway, was engaged by the Commonwealth Government as controlling and consulting engineer in connection with the survey of the transcontinental railway between Port Augusta and Kalgoorlie, and when the Commonwealth railway construction branch was formed in 1910, he was appointed Engineer-in-Chief in charge of the department. Mr. Deane built a considerable portion of the East-West Railway, meeting with many difficulties in taking a line about 1100 miles through an almost waterless and uninhabited region. He severed his connection with the Commonwealth railways in 1914, and since then practised in Melbourne as a consulting engineer.

Mr. Deane was well known to those connected with scientific institutions throughout Australia, and was a member of this Society for 39 years, having joined in 1885. He was first elected a member of the Council in 1890, and was President in 1897 and again in 1907. In 1894 he was President of the Institution of Surveyors of New South Wales. He was President of the Linnean Society of New South Wales in 1895, and also in 1896.

He was a Member of the Institute of Civil Engineers, a Fellow of the Royal Meteorological Society, a Fellow of the Linnean Society of London, and a Fellow of the Royal Horticultural Society. He was a great lover of horticulture, and a keen student of Botany and Palæontology; also a recognised authority on the Tertiary flora of Australia, to which subject he made valuable contributions. His interest in the genus *Eucalyptus,* inspired and stimulated by his early association with the late Rev. Dr. William Woolls, is evidenced by his many writings on this interesting group of trees, much of his work having been published in the Proceedings of the Linnean Society of New South Wales in collaboration with Mr. J. H. Maiden. As late as August, 1923, Mr. Deane attended the Melbourne session of the Pan-Pacific Science Congress, and took considerable interest in the Forestry section.

Mr. Deane possessed a natural, unassuming character, embodying gentleness, integrity, and wisdom, which at all times called forth our affection and our admiration, and his absence from our future scientific assemblages will be greatly felt by many of his confrères. He died at Malvern, near Melbourne, on the 12th March, 1924, at the age of 77, and was buried in the Brighton cemetery. He is survived by a widow, three sons, and four daughters.

Dr. Jacob Robert L. Dixon was born on the 16th October, 1861, at Liverpool, England, and was educated at the Royal Infirmary Medical School, Liverpool. He was silver medallist in Medicine, Surgery, Pathology and Obstetrics in his third year subjects in 1882, and in 1884 obtained the degrees of L.R.C.P., Edin., and M.R.C.S., England. In his early days he was Hon. Pathologist to the Royal Southern Hospital, Liverpool, and for many years was in private practice in the South of England, coming to

Australia from Torquay in 1912. For a few weeks he carried on at Newcastle the Port work of Dr. L'Strange Eames, but very soon was appointed Demonstrator in Physiology at the Sydney University, and somewhat recently received the appointment of Lecturer in Micro-Histology. His knowledge of microscopy was of a high order, and he had a great love for natural history.

Dr. Dixon joined the Royal Society in 1916, and died on the 27th October, 1923, leaving a widow. He was buried in the Northern Suburbs Cemetery.

Ernest Brougham Docker was born at Thornthwaite, near Scone, New South Wales, in April, 1842. He was a son of the late Joseph Docker, M.L.C., and was educated at the Collegiate School, Cook's River, and the Sydney University, where he had a brilliant career. He won the Denison Scholarship at St. Paul's College in 1860. The following year he took the University medal for English verse, and in 1862 won the Wentworth medal for English essay. He took his B.A. degree in 1863, and his M.A. degree two years later.

Judge Docker was called to the New South Wales Bar in 1867, and was appointed Crown Prosecutor in 1875. He was elevated to the position of District Court Judge of the north-western district in 1884, carrying out the duties of the latter position until 1912, when he was appointed Judge of the Metropolitan District Court. In 1894 he was appointed Judge to hold a Court at Norfolk Island. He retired from the District Court Bench in 1918. His death took place at Elizabeth Bay on the 12th August, 1923, and he was buried at South Head Cemetery.

Judge Docker was a member of the Council of the King's School, of the Church of England Synod of the

Sydney diocese, and of the Bathurst diocese, also of the Royal Australian Historical Society and of the Photographic Society of New South Wales, of which latter Society he was President from 1894 to 1907. He was one of the oldest and most beloved members of our Society, and, having been elected in 1876, his membership extended over a period of 47 years. He was also one of the most regular attendants at the general monthly meetings, and frequently at those of the Section of Geology, and was with us almost up to the time of his death. He was in the very front rank of amateur photographers in this State, and was always ready to allow the fullest use to be made of his beautiful pictures and lantern slides, which have contributed towards the success of many an address given by members of this Society. He was always delighted when his art as a photographer could be utilised to illustrate and illuminate some point of natural science. His was a personality which at all times commanded our affection and respect.

Judge Docker's wife. who was a daughter of the late Archdeacon Tucker, predeceased him, having died in June, 1918. He is survived by two sons and seven daughters.

James Henderson was born on the 20th June, 1850, near Inverkeithney, Banffshire, where his family for generations had been farmers. He was educated at a school in Aberdeenshire, and at the age of 17 was apprenticed to Messrs. J. and J. Crombie, proprietors of the Granholm Mills, Aberdeen. He became secretary, and later vice-president, of the Glasgow Shorthand Writers' Association. In 1870 Mr. Henderson entered the counting-house of Mr. T. R. Johnstone, a Glasgow merchant, and became cashier within two years. After occupying this position for six years he was advised, for health reasons, to leave for Australia.

Mr. Henderson left Scotland in 1878 by the R.M.S. *Chimborazo,* which vessel went ashore near Jervis Bay, and was wrecked, though all the passengers were rescued. He soon secured a position in Sydney with the Bank of New South Wales, and three years later joined the English, Scottish and Australian Bank, and was accountant when, in 1887, the position of assistant manager of the City Bank of Sydney was offered to and accepted by him. Ten years later he was appointed general manager, which position he filled with distinction until his retirement at the end of 1916. He died on the 18th July, 1923, and was buried at the Field of Mars Cemetery.

Mr. Henderson was a Fellow of the Royal Economic Society, and nearly 40 years ago he contributed to the "Sydney Morning Herald," a series of articles on "Land and Currency," and later, another series on "Early Colonial Banks." Many papers were read by him before the Australian Economic Association, and the Bankers' Institute of New South Wales, of which latter organisation he was vice-president at one period. He was a member of the Royal Society of New South Wales for 24 years, having joined in 1899. In his early days he was an excellent horseman, and always took a practical interest in sport. He is survived by his widow, who was a daughter of the late Mr. R. P. Richardson, two sons, and two daughters. Another son was killed on active service.

William Edmund Kemp was born at Newtown, near Sydney, on 12th June, 1858, and was a son of the late Mr. W. E. Kemp, at one time Architect for Public Schools.

He entered the Public Works Department on the 1st June, 1875, and was appointed Engineering Assistant in 1878, and Resident Engineer in 1884. Between the years 1884 and 1897, Mr. Kemp was engaged principally in con-

nection with the Newcastle Harbour Works, Hunter River District Water Supply, including the towns of Maitland and Newcastle, the Lake Macquarie Harbour Works and Manning River Entrance. In 1898, he was appointed assistant to the late Mr. L. A. B. Wade, in connection with the water supply to the country towns of the State. During most of the period from 1899 to 1912, Mr. Kemp was in charge of the Harbour Works at the Richmond and Clarence River Entrances. He was also some years District Works Officer in charge of the Lismore District. In 1915 he was appointed Resident Engineer-in-Charge of the Coff's Harbour Improvement Works under Messrs. Norton Griffiths Ltd., and when the works came back to the control of the Department, Mr. Kemp retained his position as Engineer-in-Charge of their construction until the time of his death.

He was elected an Associate Member of the Institute of Civil Engineers in 1889, and a member of the Royal Society of New South Wales in 1914.

Mr. Kemp's long experience in engineering matters both as regards Water Supply and Harbour Works, and his sound judgment, made his services of very great value to the officers under whom he was placed. He died at Coff's Harbour on the 1st May, 1923, and was buried at the Gore Hill Cemetery, North Sydney.

Alfred Lee was born near Dublin in 1858, and was taken to New Zealand at the age of four, his people having received a grant of land there. He came to Sydney when about 14 years old, and was for nearly fifty years connected with the firm of Enoch Taylor and Co., Australia and London, becoming a partner in 1888. He was a great reader, a keen horticulturalist, and a good sportsman, having indulged in cycling, football, tennis, golf and fish-

ing. For many years he devoted much time to collecting books on Australia, New Zealand, and the Pacific Islands, and these, which included some rare publications, were obtained from him by the late David Mitchell to add to the Mitchell Library collection.

Mr. Lee was a life member, and one of the founders of the Royal Australian Historical Society, and was a member of the Royal Society of New South Wales for seventeen years, having joined in 1906. He died at Glen Roona, Bondi, on the 2nd August, 1923, and was buried at the Waverley Cemetery. He leaves a widow, one son and three daughters.

James Edward Miller was a member of this Society for eighteen years, having been elected in 1905. He was born on the 23rd November, 1865, and joined the Police Service in 1885. He attained non-commissioned rank on the 1st April, 1892, and was made Acting Inspector on 1st July, 1909. At the time of his death he held the rank of Superintendent 1st Class. Since joining this Society he was stationed at Cobar, Walgett, Inverell, Broken Hill and Albury. Mr. Miller, who was a bachelor, died at Albury on the 23rd August, 1923.

PAN-PACIFIC SCIENCE CONGRESS.

To lovers of science, the event of the year was the holding of the second, or 1923, Pan-Pacific Science Congress at Melbourne and Sydney, in August last, the first Congress having been held at Honolulu in August, 1920. The holding of this most important meeting was made possible by the generosity of the Commonwealth and State Governments, and, of the latter, particularly those of New South Wales and Victoria, in which States the meetings were held. Most gratifying help, both financial and otherwise, was also furnished by many citizens in both Sydney and Mel-

bourne; in fact, the whole movement, which was under the auspices of the Australian National Research Council, was so heartily supported on all sides that it soon became evident the people of Australia had realised that a great compliment had been paid to the Commonwealth, in giving it control of the arrangements for such an important national event, and all wished to contribute towards its success. It was also made clear that the value of science, in its broadest sense, was fully recognised and appreciated. This whole-hearted support was most gratifying and helpful to those entrusted with arranging the details of the meetings.

The response from abroad was of an equally pleasing nature, and eighty distinguished overseas scientists were present at the Congress, worthily representing the various countries having interests within or bordering the Pacific. The representation was distributed as follows:—Great Britain, 12; United States of America, 17; Honolulu, 6; Philippines, 5; Japan and Formosa, 10; Netherlands and Dutch East India Government, 5; Canada, 3; New Zealand, 13; British Malaya, Fiji, Hongkong, India, New Guinea, Papua, and Tahiti, 9.

In addition to the important papers read by those present at the meetings, many valuable contributions were received from invited scientists who were unable to visit Australia.

At the Honolulu meeting in 1920, it was arranged that the subjects to be dealt with should include only those which had a definite bearing on Pacific problems, and such sciences as were regarded of world-wide application, without any special reference to the Pacific, were omitted. As a result of action taken at the 1923 Congress in Aus-

tralia, consideration is being given to the question of widening the scope of the subjects at future Pan-Pacific Science Congresses.

Matters dealt with at the Australian Congress embraced the following subjects:—Agriculture, Veterinary Science, Anthropology and Ethnology, Botany, Forestry, Entomology, Zoology, Geography and Oceanography, Geology, Hygiene, Geodesy and Geophysics, Pacific Radio Telegraphy, and Longitude by Wireless.

Some evidence of the importance with which this Congress was regarded by other countries, may be gauged from the fact that the United States of America sent the new scout cruiser "Milwaukee," equipped with the sonic depth finder, which took a new set of soundings on the voyage across the Pacific. The cruiser arrived with dramatic suddenness on the eve of the Sydney meeting, and her Commander, Captain W. W. Asserson, came as a delegate to the Congress from the United States Navy Department, and read a paper on the principle of construction and use of the sonic depth finder.

A feature of the Congress was the provision for discussions between sections having a common interest in a particular subject, though from a different point of view. These discussions proved of immense interest and of great value.

Popular science lectures, which were open to the public and attended by large audiences, were given by distinguished visitors, and the appreciation shown for these lectures was gratifying in the extreme.

At the final general meeting it was resolved:—

1. That this Congress recommends the establishment of a permanent organisation of the scientific institutions and

individuals engaged in research on the scientific problems of the Pacific region;

2. That the President of the Third Pan-Pacific Science Congress request the National Research Council or similar institution or agency of each of the following countries, viz.: Australia, Canada, Chile, France, Great Britain, Japan, Netherlands, New Zealand, the Philippine Islands and the United States of America, to appoint a member of an Organisation Committee, the Chairman of the Committee to be a resident of the country in which the Congress will be held, and that the Committee be empowered to add to its membership representatives from other Pacific countries.

It was arranged that the third Pan-Pacific Science Congress should be held in Japan in 1926, under the auspices of the National Research Council of Japan.

These congresses aim not only at the promotion of the study of scientific problems of common interest in the Pacific, but also at the maintenance of harmonious relations between all countries within and bordering the Pacific region. It is beyond question that the recent Congress was successful from the scientific point of view in advancing the knowledge of the Pacific, for no meeting such as this, composed of so many of the brightest intellects from overseas, could assemble and participate in an interchange of views without mutual benefit in the highest degree. The outstanding success, however, which was patent to every observant person throughout the Commonwealth, was the wonderful advance made in strengthening the harmonious relations between peoples widely scattered throughout the Pacific region. This work of promoting goodwill and maintaining the most friendly relations between residents of the Pacific is of paramount importance, and helps in the wider scheme of the great brotherhood of science, which aims, among other things, at assisting in cementing the bonds of peace between countries all over the world.

AUSTRALIAN RESOURCES OF LIQUID FUELS.

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NEED FOR INVESTIGATION.

So far, no mineral oil has been discovered in Australia in commercial quantities, and having in view the vast importance to this country of such a commodity, it becomes desirable in the highest degree fully to investigate the possibilities of its existence within the Commonwealth, and to examine the sources where it is possibly conserved, or to find a suitable substitute.

The use of petroleum now enters so much into the activities surrounding our industrial lives, and is so vital in connection with matters relating to defence, that the questions, as to whether the world's supply from oil wells will continue for a lengthy period to meet future increasing demands, and, if not, whence a substitute is

to come, may very properly receive the fullest consideration. On all sides the substitution of liquid fuels for coal may be seen, and the likelihood of practically all the steamships of the immediate future adopting liquid fuel as a motive power is abundantly apparent.

In an address delivered to the National Oil Shale Conference, America, in 1923, Dr. Victor C. Alderson stated that, although the United States is the greatest oil-producing nation on earth, yielding two-thirds of the world's supply, yet the domestic demand for oil, in every one of its forms, is greater than the supply. He also said that if to the well oil is added the oil that may be derived from shale, that country may justly be regarded, from the point of view of fuel, as the most favoured nation on earth.*

Mineral oil, like gold, does not replenish itself once it is taken out of the earth, and although supplies may be sufficient for many years, it is impossible to forecast their actual duration.

It is difficult adequately to appreciate the extreme importance and value of a good supply of mineral oil to any country. In regard to the position in America, the following statement made in December, 1923, by Mr. H. C. Hoover, United States Secretary of Commerce, serves to illustrate the paramount importance of this question in that country. Mr. Hoover stated:—"As a result of a survey of our own and the world situation, it is evident that our domestic sources of oil will last only a generation at the present rate of exhaustion. Meanwhile, foreign nations are rapidly pre-empting the

*The Mining Congress Journal, Vol. 9, No. 10 (October, 1923). See also Quarterly of the Colorado School of Mines, Vol. 18, No. 4 (October, 1923).

available foreign oil-bearing territory. Unless our nationals re-enforce and increase their holdings abroad, we shall be dependent upon other nations for the supply of this vital commodity within a measurable number of years. The truth of the matter is that other countries have conserved their oil at the expense of our own. We must go to the foreign fields, and in a big way."*

This most candid exhortation to America to go abroad and secure all the oil it can, while conserving its own supplies, surely has a significance which should not be lost on Australia, and is a reminder that it is imperative that an investigation of a highly scientific and technical character should be undertaken forthwith into the whole of the possibilities of an Australian liquid fuel supply, so that, at least for defence purposes, the Commonwealth, if it is at all possible, may be self-contained in regard to this "vital commodity."

Of the world's oil production to date, North America has contributed upwards of 60 per cent., and Europe upwards of 30 per cent., and although the supply in the United States in 1923 was sufficient to meet its demands, yet at the present time, owing to the extension of the number of avenues for its use, and a slightly reduced output, the position has changed from one of surplus to one of sufficiency with prudence. The inflation of supplies in 1923 came from some important and valuable discoveries in California and Oklahoma, but for the present, at least, the peak in the Californian production has been passed.

According to "The Mining Journal" (March 8, 1924), the total production, consumption, and imports of crude oil in the United States for the month of January, 1924

*"The Saturday Evening Post," December 22, 1923, p. 49.

(in barrels), were as follows:—Production, 56,354,000; consumption, 62,686,000; imports, 6,303,000.

In a valuable paper by R. E. Thwaites, issued under the direction of the Commonwealth Institute of Science and Industry, it is stated that in 1923 the United States and Mexico produced about 90 per cent. of the world's supply of crude petroleum.*

WORLD SUPPLY OF PETROLEUM.

According to "Mineral Industry," 1922, the world's marketed production of crude petroleum for the year 1922 was 851,540,000 barrels of 42 United States gallons (equivalent to 35 Imperial gallons).

The principal producing countries in 1922 were:—

United States of America ..	551,197,000	barrels.
Mexico	185,057,000	„
Russia	35,091,000	„
Persia	21,154,000	„
Dutch East Indies	16,000,000	„
Rumania	9,817,000	„
India	7,980,000	„
Peru	5,332,000	„
Galicia	5,110,000	„

Japan, Argentine, Trinidad, British Borneo and Venezuela also each produced upwards of 2,000,000 barrels, and Egypt just over 1,000,000 barrels during 1922.

A record output by the United States of about 745,000,000 barrels is expected for the year 1923.

AUSTRALIAN CONSUMPTION OF LIQUID FUEL.

No definite information can be obtained as to the *consumption* of liquid fuel in Australia, but the importations

*"The Production of Liquid Fuels from Oil Shale and Coal in Australia," Bulletin No. 24, by R. E. Thwaites, M.A.

into Australia during the year ending 30th June, 1922, were as follows:—

	Gallons.	Value. £
Kerosene and other refined petroleum burning oils	15,878,390	779,024
Mineral lubricating oils	4,104,881	489,726
Petroleum spirits, including benzine, benzoline, gasoline, pentane, petrol and naphtha	33,985,098	3,084,938

The figures with regard to the importations into Australia for the year ending 30th June, 1923, are as follows:

	Gallons.	Value. £
Kerosene and other refined petroleum burning oils	21,831,749	789,635
Mineral lubricating oils	6,490,732	614,454
Petroleum spirits, including benzine, benzoline, gasoline, pentane, petrol and naphtha	45,800,212	3,485,228

The importations for the first seven months of 1923-24, *i.e.*, from 1st July, 1923, to 31st January, 1924, are:—

	Gallons.	Value. £
Kerosene, etc.	11,656,504	455,011
Mineral lubricating oils	5,153,281	453,461
Petroleum spirits, including benzine, etc.	31,882,411	2,019,763

ORIGIN OF PETROLEUM.

In considering the possible Australian resources of liquid fuel, it becomes necessary to investigate the question of the origin of petroleum, in order that we may best know where to search for supplies. This question of origin has produced much discussion among petroleum geologists, and various theories have been propounded, each suggestion having to bear the searchlight of investigation.

The genesis of petroleum has been variously attributed to:—

Inorganic Origin: including (1) hypogene causes; and (2) vulcanicity.

Organic Origin: including (1) from animal matter; and (2) from vegetable matter.

The hypogene theory is disappearing from the field of probabilities, and appears to have been little more than a supposition that hydrocarbons may have been formed by the action of water upon metallic carbides which may possibly exist beneath the earth's crust.

The volcanic origin of petroleum has been suggested, but reasonable indications of this source of origin have not been forthcoming, and, as E. H. Cunningham-Craig states, "the theory has not found acceptance among scientific observers."*

This reduces the possible sources of origin to the two organic theories, and each has its coterie of supporters. Cunningham-Craig writes (*supra*):—"There is a growing tendency at the present time to conduct researches upon the subject of the relations of coals and lignites to petroleum. Every country that contains either coal or petroleum, or both, can furnish some evidence, and it is becoming obvious to geologists that the two fuels have definite relations to each other. It has been pointed out by the writer that the three main oil-bearing horizons in Trinidad have each a carbonaceous phase in some other district, and that the two phases, petroliferous and carbonaceous, approach each other very closely in some localities. Similar evidence has been forthcoming from many countries—e.g., Venezuela, Burma, Assam, Hungary and Rumania" . . . . "Much pertinent evidence from Great Britain was also brought to light by the work of the Petroleum Research Department during the war, but unpublished, and the relations of oil to coal and to oil shale have been made clearer."

*The Mining Journal, Vol. CXLIII., No. 4650, p. 784 (October, 1923).

The work of Dr. Bergius shows that "by treating any coal containing a fair percentage of volatile matter with hydrogen under very high pressure and at temperatures up to 850 degrees F., a remarkable exothermic action is induced, and a portion of the solid fuel becomes liquified, giving as a result a product indistinguishable from heavy crude petroleum."

After quoting the valuable and important researches carried out by Dr. F. Bergius* in the attempt to reproduce some of the conditions, including heat and pressure, approximating to those that must have occurred in Nature during the formation of oil, Cunningham-Craig goes on to say:—"This leads us naturally to a consideration of the different types of vegetable deposit that are known, and their relative stages of alteration and carbonisation. Between peat and anthracite there is every gradation of deposit of vegetable origin, and it has been proved conclusively that the purest, those freest from inorganic contents, attain the coal stage earliest. Those which yield most oils on distillation are the cannels, which are impure deposits containing much inorganic matter in a very finely-divided state."

Mr. Thwaites (*supra*) states that the researches of Dr. Bergius have proved that asphaltic crude oils, tars, pitch and even coal itself, when heated in contact with hydrogen at pressures of about 100 atmospheres, to temperatures of 400°-450° C., not only undergo decomposition or cracking, but the smaller unsaturated molecules combine with hydrogen to form saturated compounds without liberation of carbon or much gas formation.

*Dr. F. Bergius in Zeitschrift fur angewandte Chemie, July, 1921.

Cunningham-Craig writes:—"A very rich and fresh torbanite, such as is found in New South Wales, would probably be entirely liquified if subjected to Dr. Bergius' hydrogenation process, but the temperature would require to be kept comparatively low."

"Now that these interesting deposits have been so fully studied, their true significance can be appreciated: they show a stage in the formation of oil from vegetable deposits, checked and arrested owing to the particular environment in each case."

In a publication by the Department of Mines, Sydney, is the following article by Leo. J. Jones:—*

"*Animal Origin.*—The supporters of this theory contend that petroleum and natural gas are formed by the decomposition or destructive distillation of animal matter that becomes enclosed and buried beneath air-tight sediments before the total decomposition of the fatty parts has taken place."

Mr. Jones points out that in certain cases "oil and gas are found in strata containing abundant animal but little or no plant remains, particularly so in the cases of the Canadian, Appalachian, Egyptian, Mexican and Persian oil-fields, where the oil, derived from neighbouring highly fossiliferous shales, is contained in sandstones."

Oils similar to petroleum have been extracted from animal fats in the laboratory.

Plant Origin.—"The similarity of the gases given off by coal in certain mines to the gas in oil-fields, and the fact that coals and lignites, on destructive distillation, yield hydrocarbons of the paraffin and olefine series similar to

*Mineral Resources, No. 31. "Notes on Petroleum and Natural Gas, and the Possibilities of their Occurrence in New South Wales" (1921).

those of petroleum, led to the early belief that petroleum was derived from coal and lignites. Crude oil has been recorded as oozing out of coal beds at Scotland, at Vendee in France, and on the Island of Trinidad."

Some authorities suggest that petroleum has been derived from the remains of gelatinous plants, such as algæ, buried under accumulating sediments and protected from decomposition. Subsequently these remains are distilled into the various oils and gases met with in nature.

In the laboratory it is possible to distil oils resembling crude petroleum from such plants.

Animal and Plant Origin.—The theory assigning the origin of oil and gas to both animal and plant remains appears to be the one most generally held. F. W. Clarke states:—*"Wherever sediments are laid down, enclosing either animal or vegetable matter, there bitumens may be produced. The presence of water, preferably salt, the exclusion of air, and the existence of an impervious protecting stratum of clay seem to be essential conditions towards rendering the transformation possible. Seaweeds, mollusks, crustaceans, fishes and even microscopic organisms of many kinds may contribute material to the change. In some cases plants may predominate; in others animal remains; and the character of the hydrocarbons produced is likely to vary accordingly, just as petroleum varies in different fields. In one region we find chiefly paraffins, in another naphthenes, and in another nitrogenous or sulphuretted oils."

It is considered by different investigators that the variations in the composition of petroleum are not only due to the differences in the organic materials from which it has been formed, but also to the physical conditions pre-

*"Data of Geochemistry," p. 744 (1920).

vailing at the time of formation and to the subsequent migration and resulting filtration that the oil has undergone.

Ziegler gives the following summary of the conditions of oil formation as determined by geological observation :—*

1. That the formation of petroleum is a general process.
2. That the original materials represent both animals and plants.
3. That the process of alteration is one of selective putrefaction and distillation, taking place under the following conditions :—
   (a) At comparatively low temperatures.
   (b) Under comparatively great pressures.
   (c) In the presence of water, usually salty.
   (d) During a great space of time.

Mr. M. E. Wilson, † while favouring the organic theories for the origin of oil, discusses those theories in the following terms :—"They are all based on a source of supply for the oil in the organisms which have been imbedded in the rocks. . . . . The earliest theories were based on a source of supply from the remains of plants associated with the coal deposits. The abundance of plant life during certain geologic periods was well known, and natural gas has been found in coal beds at many localities. However, the great deposits of petroleum are not directly associated with deposits of coal, and the type of oil produced from the distillation of coal is chemically very different from petroleum. It is believed by some that asphaltic oils are mainly derived from animal remains, and the paraffin oils from plants. Coal has been produced from terrestrial vegetation which was certainly not sufficiently abundant

*Ziegler, "Popular Oil Geology," p. 32 (1918).

†"The Occurrence of Oil and Gas in Missouri," by M. E. Wilson, Missouri Bureau of Geology and Mines, p. 3 (1922).

throughout all of the geologic periods to have produced the wide geologic distribution of petroleum deposits. It seems, therefore, in postulating the source of petroleum from plant remains, that marine plants must be looked to with greater favour than terrestrial plants. Marine plant life also has been abundant, and it is believed that some of our great deposits of oil can be directly traced to these. It is also known that some sea plants give rise to petroleum through decomposition. There is, therefore, good reason to believe that a part at least of the petroleum deposits have been derived from the remains of marine plants."

"There are a very large number of adherents to the theory that petroleum is derived through the slow decomposition of animal matter which has been imbedded in the rocks. Much weight is given to this theory by the fact that animal matter can be converted into oils similar to petroleum in the laboratory, that animal remains are very abundant in the rocks from which the oil is produced, and that the process of conversion of certain of the animal parts into mixtures of hydrocarbons is not difficult of explanation. In fact, there is not much doubt on the part of many students of the subject, but that some of our great oil deposits were derived from the remains of animal organisms in the rocks.

"There are objections to the theory of exclusive origin of oils from animal remains the same as to the theory of exclusive origin of oil from vegetable remains, which have given rise to compromise theories, suggesting that both have played their part in furnishing a source of supply for the petroleum."

From our present store of information on the subject, it would seem that the theory of a separate or combined animal and vegetable origin for mineral oil would probably find most favour, and as the occurrence of oil is very

often associated with saline conditions of deposition, it would appear not unlikely that the vegetable matter which assisted to cause the production was marine algæ.

CONDITIONS FOR OCCURRENCE OF MINERAL OIL.

Commercial supplies of petroleum are only found in sedimentary rocks, except in very rare instances, where they may occur as migratory deposits in reservoirs contained in metamorphic or igneous rocks.

M. E. Wilson* concisely quotes certain fundamental geological requirements which are regarded as of vital importance in connection with the occurrence of commercial deposits of oil or gas. These are:—

(1) A source from which the fuels may be derived.

(2) Reservoir or a stratum of rock which is capable of storing a commercial supply in its pore space or openings.

(3) Cap rock or an overlying bed of rock so impervious as not to permit the upward escape of the oil.

(4) Some structural or textural condition of the rocks which favours a local accumulation.

Opportunities for seepages, and the irrevocable loss of some of the oil, are likely to occur where the rocks have been highly folded or fractured, or deeply dissected, as are the Blue Mountains in New South Wales, much oil thereby escaping over a long period, which might possibly have once been conserved, and, on the law of probabilities, the older the rocks the greater is the likelihood of considerable folding having taken place. The result is that there are a greater number of productive oil-fields in geological areas which are newer than Carboniferous than in

*"The Occurrence of Oil and Gas in Missouri," by M. E. Wilson, Missouri Bureau of Geology and Mines, p. 6 (1922).

those older than that period, and at the present time it is considered that more than half the petroleum of the world, perhaps quite sixty per cent., comes from rocks of the Tertiary period, one of the newest formations.

As soon as oil-bearing rocks have been folded and fractured, they commence to lose their oil, and seepages occur and continue perhaps over an enormous period of time, until the bulk of the oil has gone. Many of the oil-fields of to-day occur in the newer formations where this process of discharging the oil by seepage is in progress, and it is by this very action that attention is drawn to the presence of the oil.

Petroleum is not found in commercial quantities in igneous or intensely metamorphosed rocks. It has been found in formations as new as Quarternary (Pleistocene), and in all those ranging down to as old as Cambrian, and although it may be found in payable quantities in either Silurian, Ordovician, or rarely Cambrian, it is not often known to occur in exceedingly prolific quantities in rocks of any of those ancient periods, exceptions being in the Pennsylvanian areas.

Migration of Oil.—(1) *Gravitation*: M. E. Wilson (*supra*) points out that oil is naturally subject to the force of gravity, and where more effective forces are not involved, it will respond to the pull of gravitation. "The rocks commonly contain more or less water and it is probably very exceptional to find decidedly porous rock which is dry. For these reasons gravitation has not exerted nearly so strong a direct influence on the movement of oil through rocks as have other causes, though it is more indirectly a most important factor. The rare occurrence of oil pools in synclines or basins in the rocks, which would be brought about directly by the force of gravity, are far less common than occurrences beneath anticlines.

or upwarped arches where the accumulation has been brought about by forces tending to counteract the natural effect of gravity on oil."

(2) *Capillary Attraction*: Wilson refers to the well-known effect of capillarity, which causes oil to rise in a lamp wick, or ink to be absorbed in a blotter, and points out that the effect of capillarity in causing the movement of oil is much greater than that of gravity, though it is effective only in the finer grained rocks, and ceases to be a factor of movement in very coarsely porous rocks.

POSSIBILITIES OF THE OCCURRENCE OF PETROLEUM IN AUSTRALIA.

Rocks corresponding to the whole of the geological formations in which petroleum occurs are found in Australia, but those rocks which are older than Devonian are in many cases either highly folded or at least tilted, and often considerably metamorphosed. Our greatest hope, therefore, will not lie in the probability of discovery in these older formations, though the possibility may not be absolutely excluded, especially where these formations are still undisturbed, as in north-western Australia.

Having in view that the consensus of opinion in regard to the origin of petroleum now favours the theory that it is derived from either animal or vegetable matter, or both, it is obvious that we should look among highly fossiliferous sedimentary rocks in order to find the distributing centre or original home of this mineral oil. It would also seem possible that these likely oil-bearing rocks would be of marine origin.

There are large deposits of Silurian fossiliferous limestone of animal origin in Australia, much of which occurs in New South Wales, and it seems possible that these animal remains may have been sufficiently abundant to

have formed a source for mineral oil in some quantity, but during the process of folding, and chemical alteration of the rocks, the great bulk of the oil has probably been lost. The same generalisation applies to sedimentary rocks of the Devonian age, although these strata are less disturbed than those of the older periods, and, in addition to animal remains, contain a fossil plant—*Lepidodendron australe.*

Coming upwards to the Carboniferous formation, we reach the period where the second latest rock folding of any considerable extent occurs in Australia. The rocks of this period contain both animal and plant remains.

The Permian (Permo-Carboniferous) formation, though strongly folded in some places, contains considerable quantities of both animal and plant remains, those of the former being largely marine, while those of the latter are chiefly terrestrial, and have gone to form coal seams, these constituting Australia's most valuable deposits of coal. There seems reason to consider that the conditions necessary for the transformation of vegetable matter into coal, are not the same as those which are required to cause similar vegetation to become mineral oil. At the same time the coal conserves in some degree the ingredients necessary for the production of oil under a system of distillation.

The Triassic formation is of fresh-water origin, and characterised by the paucity of fossils. The thick uniform character of the beds comprising the Hawkesbury and Narrabeen Series of this formation, consisting of sandstones and shales, devoid of limestone or marly bands, deposited for the most part under atmospheric oxidising influences, are most unfavourable for the occurrence of oil, and experience in other parts of the world has shown similar rock types to be barren.

There would thus appear to be little, if any, prospect of ever obtaining commercial supplies of oil from such beds.

The remaining newer systems, which include Jurassic, Cretaceous and Tertiary, in an ascending scale, are composed of beds which, for the most part, are little disturbed in Australia, and contain both animal and plant remains. Provided suitable geological structures occur within these formations, they offer possibilities as a source of supply.

Thus the Tertiary, Cretaceous and Jurassic formations, together with the Permian, and in some cases the Carboniferous rocks, would appear to afford the most likely places where petroleum might be successfully sought.

As against this, however, a shaft about 2900 feet deep has been sunk to the coal at Balmain, Sydney, from near the top of the Triassic beds into the Permian rocks without revealing a trace of mineral oil. Several shafts, some exceeding 1000 feet deep, have been sunk to the coal in Permian formation near Maitland, without any oil being seen, and the same applies to bores which have been put down with a diamond drill. Gas is, of course, met with at a depth, but this is not remarkable seeing that portion of the formation penetrated is of a carbonaceous nature.

It would seem that the question which has to be solved is whether the amount of animal and vegetable remains quite apart from coal and shale, in the rocks of Australia, is sufficient to have supplied mineral oil in anything approaching commercial quantities, and, if so, whether such oil has been retained. Much of the evidence so far obtained during the somewhat limited investigation which has been made is not yet convincing, though the possibility of success still remains, and the question can only be answered by further careful geological survey and boring.

WHAT OF AUSTRALIA'S HERITAGE?

Liquid fuel has become a matter of such vital importance to the progress of all the leading nations of the world that it is imperative Australia should ascertain her possibilities in this connection. Even if petroleum should be found in payable quantities in the Commonwealth, its duration will have its limitations. It is prudent to look for other sources, and in doing so we are reminded of Australia's great heritage in her coal and oil-shale supplies.

Apart from the possibility of finding mineral oil, the sources of supply of liquid fuel in Australia are coal, oil-shale, and vegetation. The most important of these is coal, and yet at the present time comparatively little is being done to produce any liquid fuel from the great bulk of the coal which is being won, the greatest exception being the production of some liquid fuel or motor spirit by the Broken Hill Proprietary Co. Ltd., at Newcastle, and which amounts to about 1,000,000 gallons annually, or about two per cent. of Australia's present annual importations.

RESERVES OF WORKABLE COAL IN AUSTRALIA.

The following estimates of the coal resources of Australia can only be considered as rough approximations. Much more detailed geological work must be done, especially in New South Wales and Queensland, before these resources can be estimated with any approach to accuracy.

For New South Wales the present estimate has been prepared by the officers of the Geological Survey, under the direction of Mr. E. C. Andrews, Government Geologist.

For the other States the information has been supplied by the various Government Geologists.

In the Mineral Resources of New South Wales (1901), Mr. E. F. Pittman points out that attempts to calculate

the quantity of coal available in any large area of country are always more or less hazardous, and states that—"Some years ago the late Mr. C. S. Wilkinson, Geological Surveyor-in-Charge, estimated that, within a depth of 4,000 feet from the surface, the New South Wales coal seams, of a thickness exceeding two and a half feet, are capable of producing 78,198,000,000 tons of coal, allowing one-fifth for loss in working."

Subsequently, in 1890, an estimate by Professor (now Sir) T. W. Edgeworth David gave between 130,000,000,000 and 150,000,000,000 tons, not taking into consideration seams of less than three feet in thickness.

After reviewing the position in 1901, Mr. Pittman suggests about 115,000,000,000 tons as the amount available, but makes it clear that the data are insufficient for anything like accurate determinations to be reached. The figures quoted may therefore only be assumed as chiefly indicating possible reserves, the actual reserves being considered to be very much less.

NEW SOUTH WALES.

In the following estimate of actual reserves, no account has been taken of coal below 4000 feet from the surface, and the coal has been classified into three grades:—

Grade A: Coals of first grade quality, suitable for steam raising, gas making, and household purposes. Ash from five to twelve per cent.

Grade B: Coals with lower calorific value and higher ash contents than Grade A, but suitable for use in the condition as mined. Ash averaging from twelve to twenty per cent.

Grade C: Coals from inferior seams generally with high ash content, but suitable for use after washing or flotation.

1. Upper Coal Measures.

Approximate tonnage of commercial coal in New Wales.

(a) Northern Coalfield—including Curlewis.

A Grade	2,150,400,000	tons
B „	2,630,400,000	„
C „	4,300,400,000	„

Muswellbrook Coalfield.

B Grade	480,000,000	tons

(b) Southern Coalfield—including Douglas Park—Berrima.

A Grade	2,162,760,000	tons
B „	573,120,000	„
C „	1,930,420,000	„

(c) Western Coalfield—including Talbragar.

A Grade	720,000,000	tons
B „	720,000,000	„
C „	1,920,000,000	„

(d) Coorabin (Riverina) Coalfield.

A Grade	(?)	
B „	14,400,000	tons

II. Middle Coal Measures.

(e) East Maitland Coalfield—including Rix's Creek.

A Grade	345,600,000	tons
B „	702,700,000	„

III. Lower Coal Measures.

(f) Maitland Coalfields—Lower or Greta Coal Measures.

A Grade	1,324,800,000	tons

(g) Muswellbrook Coalfield—Lower or Greta Coal Measures.

A Grade	96,000,000	tons

Totals:—

A Grade	6,799,560,000	tons
B „	5,120,620,000	„
C „	8,150,820,000	„
Aggregate	20,071,000,000	„

This includes the amount already won, nearly 300,000,000 tons, but as the estimate is only approximate at best, the aggregate quantity might be stated at about 20,000,000,000 tons of actual reserves, while the possible reserves may be accepted for the present, as about 100,000,000,000 tons, in addition.

Practically the whole of the New South Wales coals belong to the bituminous group.

It is difficult to decide what allowance should be made for the loss of coal in winning, for it is impossible to say what improved methods of mining may be evolved in the future, though it is beyond doubt there will be some considerable loss. In the Hetton and Stockton Collieries, under harbour and ocean waters at Newcastle, the bords worked were six yards and the pillars left were eight yards wide, so that nearly sixty per cent. of the coal, which is of excellent quality, has been left. These collieries are now filled with water, but there are mining engineers who forecast the possibility of much of this abandoned coal even yet being won by a system of hydraulic stowing, when the pressing need for coal arrives.

For the purpose of this calculation a twenty per cent. loss will be adopted, so that the actual coal reserves will be considered to be about 16,000,000,000 tons.

The enormous asset which New South Wales has in its coal may be comprehended by estimating the known reserves of about 16,000,000,000 tons at £1 per ton, thus giving a value of £16,000,000,000, and if to this be added the possible reserves, less 20 per cent. which may be lost in working, the value reaches the fabulous figure of about £96,000,000,000 for this State alone.

Average Proximate Analyses of N.S.W. Coals.

The following average proximate analyses have been calculated from a series of analyses made by the Chemists

and Analysts' Branch of the Mines Department, under Mr. J. C. H. Mingaye.

	Greta Seam	Borehole Seam	Burwood Seam	Tomago Seam	Bulli Seam	Lithgow Seam
Hygroscopic Moisture	1.960	2.24	2.43	2.52	0.64	2.29
Volatile Hydrocarbons	40.570	34.98	34.04	33.82	23.18	30.62
Fixed Carbon	50.740	54.77	53.60	51.79	65.21	53.34
Ash	6.730	8.01	9.93	11.87	10.97	13.75
Sulphur	1.168	0.470	0.367	1.082	0.367	0.756
Specific Gravity ..	1.291	1.339	1.338	1.349	1.378	1.441
Calories	7,275	7,381	6,876	6,681	7,274	6,554

VICTORIA.

Information received from Mr. W. Baragwanath, Government Geologist.

Approximate tonnage of extractable *Black Coal*:—

Korumburra, Jumbunna, and Outtrim	2,000,000 tons
Wonthaggi	20,000,000 „
Total (including several small outside areas)	25,000,000 „

Brown Coal.

Estimate as ascertained by boring in various Victorian areas:—

	Tons.
Morwell and District	5,000,000,000
Traralgon and District	5,000,000,000
Walshpool-Gelliondale	250,000,000
Altona	100,000,000
Lal Lal	25,000,000
Wensleydale	3,000,000
Total	10,378,000,000

QUEENSLAND.

Mr. B. Dunstan, F.G.S.* estimates the area of the Coal Measures of Queensland to be 73,000 square miles, of which 20,000 square miles are made up of recognised coal fields,

*Queensland Geological Survey Publication No. 239, "Coal Resources of Queensland," by B. Dunstan, F.G.S. (1913).

namely, 2,000 square miles of Cretaceous age, 2,000 square miles of Trias-Jura age, and 16,000 square miles of Permian age.

The estimated coal reserves include all seams not less than one foot thick and situated at depths not greater than 1,000 feet below the surface.

One square mile around a spot where a coal seam is known is taken as the limit of probability.

The total actual reserves of coal are estimated to be 412,120,000 tons, as under:—

	Tons
Semi-Anthracite	122,500,000
Bituminous	279,250,000
Semi-bituminous	2,600,000
Gas Coal	7,770,000
Total	412,120,000 tons

The total probable reserves are estimated to be 1,684,000,000, as under: —

Semi-Anthracite	629,800,000
Bituminous	828,800,000
Semi-bituminous	157,400,000
Gas Coal	4,000,000
Lignite	64,000,000
Total	1,684,000,000 tons

Probable Reserves.—The principal coal areas lie in the vicinity of Beaudesert, Bowen, Burrum, Callide Creek, Chinchilla, Clermont, Cooktown, Dalby, Dawson River, Hughenden, Ipswich, Walton, Little River, Mackenzie River, Central Railway, Mount Mulligan, Nebo, Nundah, Styx River, Tiaro, Toowoomba, Warwick and Waterpark Creek.

Unprospected coal areas occur in the vicinity of Brisbane, Ipswich, Maryborough, Gladstone, Rockhampton, Mackay, Townsville and Cooktown.

SOUTH AUSTRALIA.

The Coal Mining Industry has not been established in South Australia, but the resources are considerable.

A short note on the several deposits is given by Mr. Keith Ward, in the Annual Report of the Director of Mines, 1922 (pp. 12 and 13), but, although reserves of lignite amounting to over 50,000,000 tons have been proved, it appears probable that this is only a fraction of the total resources.

This report indicates that the best coal in South Australia has been proved at depths of 2,830 and 3,950 feet on a borehole near Robe. The biggest seam intersected in this bore, however, is only three feet in thickness and the horizontal extent is not determined.

Sub-bituminous coal has been recorded at Kuntha Hill and at Lake Phillipson, far from existing lines of transport.

The large deposit at Leigh's Creek is 170 miles from the nearest port.

The composition of these sub-bituminous coals is indicated in the following table:—

Locality and Age.	Sulphur after Air drying.	Moisture at 105° C.	Volatile Matter.	Fixed Carbon.	Ash.
Kuntha Hill, Cretaceous ..	—	11.68	36.63	42.70	8.99
Lake Phillipson, Jurassic	—	21.02	39.48	33.12	6.38
Leighs Creek, Triassic ..	0.24	27.15	25.24	33.68	13.91

These deposits have been only partly explored, and no attempt has been made to indicate the total tonnage of coal.

The Tertiary lignites are known to be widespread, but the tonnage has been determined by boring at the following localities only:—

Locality.	Tonnage.	Area in Acres.	Average Thickness.	Depth.
Noarlunga	1,438,000	80	12ft. 6in.	322 ft.
Moorlands	8,175,000	389	14ft. 8in.	79 ft.
Clinton	32,384,000	620	21ft. 8in.	292 ft.
Lukeman	10,701,000	280	21ft. 7in.	242 ft.
Hope Valley ..	No estimate	200	13ft. 0in.	164 ft.

The horizontal extent of the deposits of sub-bituminous coal and the other known deposits of Tertiary lignite has not been determined. It is not possible to determine the total coal resources of South Australia until detailed surveys of the Coal Measures have been made.

WESTERN AUSTRALIA.

Coal has been extensively mined in only one district in Western Australia, namely, the Collie Coal Field, which has an area of fifty square miles.

The Royal Commissioners of 1914 on the Collie Coal Industry estimated that at a depth not exceeding 2,000 feet the available coal on the field amounts to 3,500,000,000 tons.*

The following is a table of average results of the analyses of the coals of the Collie Coalfield:—

Collieries:—	Co-operative.	Western.	Proprietary.	Scottish.	Cardiff.
Ash	7.69	8.12	6.40	3.95	4.50
Moisture	19.26	19.30	24.70	24.70	25.10
Sulphur	0.42	0.50	0.40	0.64	0.78
Nitrogen	1.12	1.13	1.15	1.04	0.92
Volatile Hydrocarbons	26.40	26.90	26.20	38.30	32.10
Calorific value, B.T.U. as received	9,803	9,779	9,112	9,354	8,988
Calorific value, B.T.U. ash, moisture free..	13,374	13,486	13,231	13,079	12,670

Other fields which have not been worked extensively are the probable extension of the Collie Coal Field at Wilga,

*Extracted from A. Gibb Maitland's "The Coal Deposits of Western Australia."

the Irwin River Coal Field, the Greenough River, Flybrook, the Vasse, Donnybrook, Millbrook and Kimberley deposits.

A few representative analyses of coal from some of these fields are given below:—

Locality:—	Wilga.	Irwin River.	Flybrook.	Donnybrook.	Kimberley.
Moisture ..	18.43	18.39	13.31	31.34	8.87
Volatile hydrocarbons	29.20	29.87	37.42	28.43	29.73
Fixed carbon.	47.13	40.13	46.45	24.37	33.99
Ash	5.24	11.61	2.82	15.86	27.41
Total	100.00	100.00	100.00	100.00	100.00
Calorific value, B.T.U.	9,253	8,593	10.167	6,315	7,722

Until detailed surveys of these fields are made it is impossible to give estimates of the amount of coal available.

TASMANIA.

The commercial value of the coal in Tasmania varies according to age. The Permian coal includes the humic kerogenites, pelionite and torbanite.

The Trias-Jura coal includes sub-anthracitic and non-caking humic coals, while the Tertiary coals are lignites and brown coal.

The total actual reserve, as given in "The Coal Resources of Tasmania," is 124,980,000 metric tons, consisting mainly of non-caking, humic coal, and 136,000 metric tons of humic kerogenites.

The total probable reserves are estimated to be approximately 123,013,000 metric tons.

This estimate includes 16,200,000 metric tons of sub-anthracitic and non-caking humic coals, and 5,300,000 metric tons of humic kerogenite, the remainder being mainly non-caking humic.

No figures are given for possible reserves.

The sub-anthracites burn with a slightly luminous short flame, and little smoke, and do not coke. They have a fuel ratio of 7 to 12, a calorific value of 15,000 to 15,500 B.T.U., or 8,330 to 8,600 calories.

The total carbon is 90 to 93 per cent., and the volatile hydrocarbons 7 to 20 per cent.

Non-caking humites burn with a short, luminous flame, have a fuel ratio of 1.4 to 7, a calorific value of 12,000 to 14,000 B.T.U., or 6,600 to 7,800 calories. The total carbon varies from 70 to 90 per cent., and the volatile hydrocarbons from 20 to 38 per cent.

The humic kerogenites burn with intumescence with a long, highly luminous flame, giving out a characteristic odour resembling, to some extent, that of burning oil. The fuel ratio varies from .8 to 1.9, the calorific value from 12,000 to 16,000 B.T.U., or 6,600 to 8,800 calories, the total carbon from 60 to 80 per cent., and the volatile hydrocarbons from 40 to 50 per cent.

The principal Coalfields in Tasmania are:—

The Mount Nicholas-Fingal-Dalmayne Coalfield.
The Seymour-Douglas River-Denison R.-Mt. Paul Coalfield.
The Swansea-Schouten Island Coalfield.
The Triabunna-Buckland Coalfield.
The Tasman Peninsular Coalfield.
The Bruny-Strathblane Catamaran Coalfield.
The Sandfly-Cygnet Coalfield.
New Town Coalfield.
The Upper Derwent Coalfield.
The Colebrook Coalfield.
The Colebrook Richmond Coalfields.
The Bagdad-Kempton Coalfield.
Mike Howes Marsh Coalfield.
The York Plains Coalfield.
The Avoca Coalfield.
Longford Coalfield.
The Mersey Coalfield.
George Town Coalfield.
Prevlenna and Barn Bluff-Pelion Coalfield.

NEW GUINEA.

The published information concerning the coal of this area is very limited.

Tertiary lignite* was found on the watershed of the Upper Purari River and in the upper channels of the Curnick River. This coal contains 18-20 per cent. of moisture, and the greatest thickness of any seam examined was 2 ft. 9 in.

Mr. Evan R. Stanley† reports that Brown Coal has been found in the vicinity of Astrolabe Bay, containing 18 per cent. of moisture and low ash. Brown coal of superior value also has been reported in the southern portion of New Ireland.

These occurrences, so far as known, are small.

Boulders of bright, glistening coals, and of good quality, have been noted on the upper reaches of certain New Guinea streams, and it is possible that commercial seams of coal may be found in this area.

CANNEL COAL, TORBANITE, AND OIL SHALE RESOURCES.

These three terms are applied to substances closely related in chemical composition, physical structure, mode of occurrence and origin, in fact they are merely divisions of a class, just as rich, medium, and poor quality coals are similarly embraced.

The generally accepted classification is as under:—

(1) Brown cannel—Applied to Kerosene Shale, Torbanite, Boghead Mineral, and Tasmanite—characterised by a preponderance of spores and pollen. Average ratio of volatiles to fixed carbon up to four to one. Low ash percentage.

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* J. E. Carne. On Purari Coal Expedition, Papua. Annual Report, 1911-12. pp. 36, 181.

† Report on Natural Resources, New Guinea. By authority. Parl. Paper No. 18, 1923, p. 64.

(2) Black cannel—Applied to ordinary cannel coals, characterised by a preponderance of carbonaceous or vegetable matter. Average ratio of volatile to fixed carbon 1 to 1. Ash percentage, medium to high.

(3) Shaly cannel—Applied to oil-shales characterised by a preponderance of mineral. Average ratio of volatiles to fixed carbon, 1 to 1. Ash percentage very high.

The term cannel is derived from Canevyl, meaning a candle, from the readiness with which the coal ignites and gives off a steady flame. Only the Brown Cannel or Kerosene Shale variety in New South Wales possesses this property. The other varieties are too low grade and contain too high a percentage of ash (mineral matter), to ignite readily. It may thus be said that so far as the Mines Department has definite information, the only cannel coal of commercial importance in New South Wales is the "Brown" or Kerosene Shale variety.

No information is available by which even a rough estimate of the quantities of Black Cannel (Oil Shales) coals could be made.

Approximate tonnage of Torbanite (Brown Cannel).

1. New South Wales. Oil Shale or "Kerosene Shale," as it is known generally in New South Wales, occurs for the most part in the form of isolated lenticular areas rarely more than a mile in length or width on certain horizons of the Upper and Lower Coal Measures.

The principal deposits yet discovered are those in the neighbourhood of Newnes (Capertee Valley), Hartley Vale, Katoomba, Murrurundi, Joadja, Baerami and Barigan. Small patches have been discovered also in the Lower or Greta Coal Measures, at Greta and Clyde River, and recently a bore in these Measures at Muswellbrook passed through a four-feet seam of kerosene shale.

The following list indicates the geographical position of the principal deposits:—

Murrurundi	115 miles by rail north-west of Newcastle.
Baerami	18 miles to railway, 120 miles west-north-west from Newcastle.
Newnes (Capertee-Wolgan Valley) ..	31 miles by private railway to Newnes Junction, which is 88 miles westerly from Sydney.
Hartley Vale	82 miles westerly from Sydney.
Katoomba	63 miles westerly from Sydney.
Joadja	18 miles by road from Mittagong, which is 82 miles southerly from Sydney.
Barigan	About 15 miles north-east from Lue, on the Mudgee Railway Line, 173 miles from Sydney.

In addition to the above localities, numbers of small areas of oil-shale are known to occur in the Capertee Valley, as at Airly and Crown Ridge.

The composition of the oil-shale varies considerably, as is shown by the following table of average proximate analyses:—

Locality	Moisture per cent.	Volatile Matter per cent.	Fixed Carbon per cent.	Ash per cent.
1. Joadja	0.52	68.10	15.03	16.35
2. Katoomba	0.66	65.86	18.60	14.88
3. Hartley Vale	0.36	71.50	6.71	21.53
4. Murrurundi	1.73	57.65	9.47	31.34
5. Capertee-Wolgan	0.45	61.36	14.13	24.04
6. Baerami	0.43	58.14	9.36	32.06

1. Calculated from analyses of fifteen samples.
2. „ „ twenty-five samples.
3. „ „ two samples only.
4. „ „ five samples.
5. „ „ eighteen samples.
6. „ „ five samples.

(No. 3 samples are from the Old Hartley Vale Mine).

The yield of crude oil per ton of kerosene shale ranges from 75 to 120 gallons for the better classes of shale. Ex-

ceedingly rich areas mined at Hartley Vale returned from 150 to 160 gallons, while as much as 170 gallons per ton has been obtained from oil-shale retorted at Joadja, although the average yield was considerably less than this figure. In recent retorting practice by the Commonwealth Oil Corporation at Newnes, the average yield was approximately 80 gallons of crude oil per ton of shale retorted.

The deposits in the Capertee and Wolgan Valleys, near Newnes, are the most extensive within the State, being proved over large areas. In thickness the seam varies from 14 to 50 inches, and, on the Capertee side, one tunnel has exposed an average thickness of between three and four feet, over a distance exceeding 4,000 feet.

The best shale has been removed from Hartley Vale, Katoomba and Joadja, but quantities of less valuable shale may be available in these areas. A considerable amount of prospecting is required still to prove the extent of the deposits at Barigan, Baerami and Murrurundi.

Several types of retorts have been worked successfully in New South Wales. In recent years retorting and refining have been done at Newnes. Here a bench of 64 retorts was erected, having a daily capacity of 100 to 120 tons of shale. From this quantity of shale, the yield of crude oil would be about 9,000 gallons, the finished products from which would be represented as under:—

	Per Cent.	Gallons
Fuel Oil	20	1800
Gas Oil	25	2250
Kerosene	20	1800
Benzine and Spirits	5	450
Wax	5	450
Loss in treatment	25	2250
		9000

By-products:—

(1) Sulphate of ammonia. About 22 lbs. of this product are obtained from one ton of shale.

(2) Oil-coke, which is obtained from the coking stills, and is used for household purposes.

It is estimated that the probable reserves of kerosene shale within the Capertee-Wolgan-Glen Alice area are approximately 20,000,000 tons. The average content of crude oil per ton of shale would appear to be about 100 gallons, giving a total quantity of 2,000,000,000 gallons, or 50,000,000 barrels available in this area, though at present only about 80 gallons per ton are recoverable.

Of the remaining deposits, those at Bathgate, Baerami, Barigan, Airly and Murrurundi appear to be the most important. At the present time, there is not sufficient information available for the estimation of the reserves in each area, but there is a high expectation that the total quantity of shale available in these deposits may approximate the estimated "Reserves" of Capertee-Wolgan. The average grade of the kerosene shale from the remaining deposits, however, would appear to be generally somewhat less than that of the shale mined in the Capertee-Wolgan areas, and the average content of crude oil per ton of kerosene shale may be approximately 75 gallons; so that the total quantity of kerosene shale expected to be won from deposits within the State may be approximately 40,000,000 tons, containing 3,500,000,000 gallons of crude oil.

SUMMARY.

THE COAL AND OIL RESOURCES OF AUSTRALIA.

1. Coal Resources.

Estimated reserves, additional reserves and possible reserves of coal in various States and Territories.

State or Territory.	Reserve Tons.	Prob. Additional Res. Tons.	Possible Add. Res. Tons.
N. S. Wales	20,000,000,000 (including small amount of probable reserves).		Very large, probably as much as 100,000,000,000—on the assumption that the undeveloped area produces only 40% by volume per acre of the known colliery areas.
Queensland	410,000,000	1,684,000,000 (approx.)	Large— 13,000,000,000 (Dunstan Min. Index, 1913).
Victoria	10,500,000,000 Brown Coal. Approx. Includes prob. Reserves, and 25,000,000 tons black coal.		Apparently not large outside reserves.
Sth. Australia	50,000,000	No estimate.	Moderately large.
W. Australia	3,500,000,000 (being combined Reserves and prob. Reserves).		Apparently not large outside reserves.
Tasmania	125,000,000	123,000,000	Apparently not large outside reserves.
New Guinea	No estimate.	No estimate.	No estimate.
N. Territory	No estimate.	No estimate.	No estimate.
Total	34,585,000,000		

2. Oil Resources.

(a) From "Oil Shale."

In this estimate, a rough indication only is supplied of the amount of crude oil recoverable from the various types of oil shale. All this oil is considered here as "crude oil" or fuel oil.

"Oil shales" occur in vast quantities in the Northern Hemisphere, but are much neglected to-day, with the exception of Scotland deposits, owing to the relative cheapness of crude or petroleum oil. Only a portion of the crude or fuel oil from bores or oil-shales, may be considered as motor spirit.

State or Territory.	Reserves and Probable Reserves.		Remarks.
	Tons.	Gallons.	
New South Wales	40,000,000	3,500,000,000	Mainly Torbanite
Tasmania	42,800,000	1,771,000,000	„ „
Queensland	Not known	Not known	Apparently small
West Australia	„	„	„ „
South Australia	„	„	„ „
Northern Territory	„	„	„ „
Papua	„	„	Very little geological work completed in Papua.

(b) From Coal.

The treatment of certain coals in New South Wales for coke-making purposes indicates that the by-products obtained during such process may be estimated to include, among other things, two gallons of light oil suitable for motor spirit, besides tar, per ton of coal. This tar constitutes an excellent fuel with a calorific value much exceeding that of the coal in equal weights, but, in ordinary circumstances, its use for fuel could not be considered a commercial procedure, because the greater portion of the tar would be too valuable for other purposes. In a national emergency, however, it might be needed as a fuel, hence its inclusion in this report as a possible source of fuel.

State or Territory.	Reserves. Gallons.	Prob. Reserves. Gallons.	Poss. Resources. Gallons.
N. S. Wales	40,000,000,000 (includes some Prob. Reserves).	Included under Reserves.	Very large, probably as much as 200,000,000,000 outside reserves.
Queensland	820,000,000	3,368,000,000 (approx.)	26,000,000,000
Victoria	21,000,000,000 (approx.)	(Combined Reserves & Prob. Res.)	Apparently small outside reserves.
Tasmania	250,000,000	246,000,000	Apparently not large outside reserves.
Sth. Australia	100,000,000	No estimate.	Apparently fairly large.
W. Australia	7,000,000,000	(Combined Reserves & Prob. Res.)	Apparently not large outside reserves.
New Guinea	No estimate.	No estimate.	No estimate.
N. Territory	No estimate.	No estimate.	No estimate.
Approx. Total	69,000,000,000		

This estimate is very conservative, as it is based on the assumption that the whole of the coal would be reduced to coke in the first place. It is, however, much more likely that a low temperature carbonisation would be adopted, whereby the quantities of light and heavy fuel oil would be very greatly increased as compared with those yielded as by-products from coke-making.

TREATMENT OF OIL-SHALES.

It has been demonstrated that retorts suitable for the treatment of low grade oil-shales are not satisfactory for dealing with high grade material, such as that which may yield upwards of 70 gallons of crude oil per ton. It would seem that much of the possible future success in regard to the treatment of some of our best oil-shales depends upon

the devising of satisfactory and improved methods of retorting. This problem, which remains to be solved, is one of great economic importance, for if the cost of production can be reasonably reduced, then the great asset which exists in the oil-shales of New South Wales, which contains some of the richest oil-shales in the world, and in Tasmania, can be availed of. Costs of mining and transport are also factors which contribute to the difficulty of obtaining profitable results.

Two retorts of different types have recently been introduced to deal with the high grade oil-shales of Australia, but there has not yet been time definitely to prove their undoubted success. In each case the retort can be run continuously, and the waste or hard gases given off the shale are utilised to maintain the heat of the retort. One of these retorts is of the internal combustion type, in which the flame is in contact with the shale, and is on somewhat similar lines to some which have already been used. Full particulars regarding the economic advantages claimed for the retort are not available.

In the other retort, the method of applying the heat to the shale is entirely different. In this case the heat is generated in an auxiliary column fitted with tubes. This column is connected with the retort at both top and bottom, and the hot air in the column is forced down by a blower at the top, and enters the retort at the bottom and passes up through the mass of shale in the retort. By the use of certain mechanical appliances the residue discharged is automatically equalled by a charge of "green" oil-shale on the top. In a number of experiments carried out in a model retort of one half ton capacity it has been demonstrated that the shale is completely retorted in from five to six hours, or in about one-fifth of the

ordinary time. Under this method, carbonisation on the walls is practically negligible. It is claimed that the nitrogenous matter in the shale is retained in the residues, and in some cases the ammonium sulphate present is equal to 42 lbs. per ton of shale treated. The residue is said to have sufficient gas in it for heating the retort. If this is found to operate in bulk treatment, it will show a definite improvement over the Scotch system, where the residues are inert.

BY-PRODUCTS FROM COAL.

A considerable quantity of coal is used in Australia for the production of gas and coke, and in the process of obtaining these two commodities, or either of them, it is possible also to secure the following by-products:—Sulphate of ammonia, distilled tar and pitch, fuel oil, creosote oil, solvent naphtha, motor benzol, and pyridine.

In the Illawarra district of New South Wales, for the five years ended 31st December, 1923, 1,312,702 tons of coke were produced, and in the process, not one of the above by-products was recovered, the whole being irrevocably lost.

	Illawarra coke produced.	Coal used for the manufacture of coke; coke estimated at 69% of coal used.
	Tons.	Tons.
1919	236,546	342,820
1920	280,568	406,620
1921	289,670	419,812
1922	191,626	277,719
1923	314,292	455,496
Total five years	1,312,702	1,902,467
Ttl., ten yrs., 1914-1923	2,833,799	4,106,955

At some of the Illawarra coke works a portion of the gas produced is turned to good account, and used for

steam raising and for generating electricity, which is made use of for purposes connected with the carrying on of colliery work, as well as for street lighting and domestic purposes, though it is thought greater use might be made of the waste gas for generating electricity.

For several years conferences have been held between the Department of Mines and the coke producers, with the object of devising means whereby this great national waste of by-products might be avoided, but the difficulty lies in the economic factor, including suitable markets, and it cannot be shown that under present conditions these by-products can be recovered at a profit. The trouble largely arises from the fact that the class of oven used in Illawarra for coke making, and known as the beehive type, is not suitable for saving the by-products, although they meet the requirements for making coke, and to scrap these structures and build by-product ovens would be a sacrifice, and would also involve very considerable expenditure. Any scheme to erect a plant solely for the purpose of recovering by-products, and not to include coke making, is, under present local conditions, considered to be unsound financially. At the same time, a valuable national asset is being gradually but surely depleted, without the State receiving full value for the commodity being used.

The words of Sir John Cadman, Technical Adviser of the Coal Mines Department, Great Britain, in his Presidential address to the Institute of Mining Engineers at Stoke-on-Trent, are worthy of being repeated here. His statement was:—"While the popular view of coal is that it is something to be burned, the scientific view was tending to be precisely the opposite. It is that coal is too valuable to be burned, that to burn it is to squander it, that the by-products of coal are of greater moment than

the coal itself, and that not until these by-products have been extracted should the residuum be used for industrial or domestic purposes.''*

The reduction of all coal to coke, however, is not yet likely to be adopted universally for the sake of the derivable by-products.

Borehole Coal.—At Newcastle, the Broken Hill Proprietary Company, Ltd., at its steel works, is manufacturing coke, and has 224 by-product ovens. Through the courtesy of this Company, I am able to say that the coal used, which is from the Borehole seam, in the Upper Coal Measures, produces per ton of coal:—

(a) Coke—12 cwts.
(b) Nut Breeze, 40lbs.—Used as blast furnace fuel.
(c) Fine Breeze, 160lbs.—Burnt under boilers.
(d) Gas—11,500 cu. feet. After being stripped of its by-products, 60% of this is required for heating the ovens, leaving 40% available for industrial heating.
(e) Tar—7 gallons.
(f) Ammonium Sulphate—23lbs. Australian market limited.
(g) Benzol (motor spirit)—2 gallons.
(h) Solvent Naphtha—0.14 gallons.

Average analysis of B.H.P. Crude Tar:—

Water		4.0%	
Light oil	0°—170°C.	2.35%	
Middle oil	170°—230°C.	10.11%	Carbolic and Cresylic acid.
Heavy oil	230°—270°C.	11.15%	=25 % of this fraction or 5.31% of tar.
Anthracene oil	270°—400°C.	18.8 %	
Hard Pitch ...		53.59%	

Greta Seam.—From investigations made, it is known that a ton of coal from the Greta seam will yield approximately as follows:—

*Transactions of the Institution of Mining Engineers. Vol. LXII. Part 4, p. 290 (1922).

Coke	10 cwts.
Sulphate of Ammonia ..	26.7 lbs.
Distilled Tar and Pitch	11.4 gals.
Heavy Fuel Oil	2.5 gals.
Creosote Oil	2 gals.
Solvent Naphtha	.5 lbs.
Motor Benzol	.9 lbs.
Gas	between 11,000 and 13,000 cubic feet, obtained by destructive distillation.

Illawarra and Western Coal.—From comparative analyses made in the Mines Department, a ton of Illawarra coal (Bulli Seam), or of Western coal (Lithgow Seam), is estimated, by Mr. H. P. White, to yield somewhat under two gallons of light fuel oil, while a ton of Greta coal, coked under similar conditions, would yield almost 2½ gallons.

Morwell Coal, Victoria.—The Government Geologist of Victoria gives the yield of fuel oil from the Morwell brown coal as 2.92 gallons.

From these results it is proposed to adopt an estimate of two gallons of light fuel oil as the average yield from a ton of Australian coal under present methods of production from coking.

If the methods which are being investigated by Dr. Bergius prove commercially successful for the manufacture of a liquid similar to petroleum by the application of hydrogen to coal, then the production of liquid fuel from a ton of coal will be increased very many times.

HEAVY FUEL OIL.

Motor spirit or motor fuel, which is vaporised for the purpose of producing power by combustion, has been referred to in this address as distinct from heavy fuel oil, which has to be burnt as other fuels for the purpose of heating and producing power from steam, and which

is used in steamboats. Heavy fuel oils are contained in the tar distilled from coal, and in the case of the Borehole Seam at Newcastle the yield of tar is about seven gallons from a ton of coal, after it has been stripped of its motor spirit, but this amount is exceeded in some of the other coals. Quite half of this tar could be converted into heavy fuel oils, though at present it is considered to be more valuable for other purposes. With so much mineral oil available, there is no pressing necessity for using the heavy oil from coal as a liquid fuel.

If a tentative figure of, say, four gallons of heavy fuel oil be adopted as the product of a ton of coal, then under present methods of extraction as a by-product, the total amount of heavy fuel oil which may be produced in Australia from coal would be twice that quoted for motor spirit or light fuel oil.

LIQUID FUEL FROM VEGETATION.

It is highly desirable that every effort should be made to investigate thoroughly all possibilities of obtaining liquid fuel from vegetation, as the supply from this source may be replenished by fresh growths of the producing plant, whereas once the petroleum is obtained from the earth, or the oil is extracted from coal and shale, there can be no further supplies from these sources.

The principal vegetable products are discussed in Bulletin No. 6 of the Advisory Council of Science and Industry (1918).

Practically all vegetable material would become a potential source of power alcohol if the price of petrol were considerably increased.

Alcohol can be produced from all substances which contain fermentable sugar or some component which can be converted into a fermentable sugar, and a convenient

list of such substances is that given in Bulletin No. 6 (*supra*).

(a) Sacchariferous substances, such as grapes, sugar cane, sorghum, and beets.

(b) Amylaceous (starchy) materials, such as maize, wheat, barley, and potatoes.

(c) Cellulose, such as saw-dust and wood lyes from paper-pulp mills.

(d) Inorganic substances, such as acetylene, from which alcohol may be made synthetically by combination with other materials.

That so many proposals to manufacture power alcohol have failed to materialise is strong evidence that at present there is no vegetable material, apart from sugar cane molasses, from which alcohol can be produced remuneratively.

Wheat and maize will yield upwards of 80 gallons of alcohol, and barley about 70 gallons per ton, but these substances are too valuable as food-stuffs to be used for the purpose of producing alcohol. Molasses will yield upwards of 60 gallons of alcohol per ton.

Molasses.—It is estimated that in 1924 about 84,000 tons of molasses will be produced in Australia, 78,000 tons of this coming from Queensland, and 6000 tons from northern New South Wales. This could, if all used for distillation, produce about 5,000,000 gallons of alcohol. These figures have been made available through the courtesy of the Colonial Sugar Refining Company Ltd.

Of the Queensland output of molasses, 40,000 tons will come from the north of Townsville, within the tropics, and owing to the sustained high temperature of the cooling water in distillation in the tropics, the value of the resultant alcohol is reduced if produced in that hot climate.

The molasses has a fuel value at the mill, so cannot be regarded as valueless even there. Before it can be turned into spirit, the molasses must be carried to the water front and shipped to the distillery, or local distilleries must be built to deal with it on the spot, and this involves corresponding charges for transport of the finished article, for fuel supplies, etc. A land freight with attendant charges of twenty shillings per ton of molasses is quite possible, which adds four pence per gallon to the cost of the spirit. A sea freight with attendant charges of thirty shillings per ton of molasses is also quite possible, which means an addition of six pence per gallon to the cost of the spirit.

A large amount of molasses is required locally for stock feed, and many of the mills are so situated that the cost of transport to any position where it could be available for alcohol is prohibitive. In this way the amount of molasses available for alcohol is materially reduced. If half of the total molasses were distilled, it would yield 2,500,000 gallons of spirit. About 1,500,000 gallons are required for industrial purposes of various kinds, hence there only remain a potential 1,000,000 gallons of molasses alcohol available for motor spirit under present conditions.

Burrawang.—This is a native plant (*Macrozamia spiralis*), which occurs in many coastal districts of New South Wales. It has a trunk of 2 or 3 feet, with a diameter of from 1 to 2 feet, and produces long palmate leaves. The trunk and the bases of the leaves have been used for the production of starch, but the results have not been very satisfactory. These Zamia palms are very plentiful on the lower portion of the Clyde River, and a treatment plant was erected a few years ago, near Currowan, above Nelligen, for the purpose of extracting the starch. Burrawangs are somewhat awkward things to

collect, which adds to the cost of the work, and the gathering and treatment are rendered more difficult from the fact that the sandy soil in which they usually grow gets deposited between the bases of the leaves and the trunk, and quickly blunts the implements used for cutting up the stems, besides rendering the extraction of the starch more difficult.

In the Bulletin No. 6 of the Advisory Council of Science and Industry the amount of alcohol (95 per cent.) which these plants may yield is quoted at 18 gallons per ton.

From information kindly supplied to me by Mr. Edward Elliott, of Reckitts (oversea), Ltd., concerning the experiments at Nelligen, it may be stated that one ton of trunks of over thirty lbs. weight, including the outer and inner core, would yield about 3 cwt. of crude starch, which, in its turn, would give up to twenty gallons of alcohol. It is possible that the direct treatment of the plant for alcohol would give much lower results. The granule of the starch is larger than that obtained from maize and rice, which is a disadvantage for the present day uses. The trunks, when landed at the works, contain at least 50% of moisture.

The following figures are the results of numerous experiments:—

	Leaves.	Core.
Proteins (soluble in water)	.25	.60
Proteins Colloidal (insol. in water)	2.90	2.35
Sugars, etc., soluble	4.85	3.95
Fibre	29.20	21.35
Starch	13.10	20.65
Water	49.70	51.10

It seems evident that any prospect of commercial success in the treatment of the Burrawang will lie in the recovery of the starch and alcohol, conjointly with the utilisation of the fibre.

Other Plants.—So far, the treatment for power alcohol of Prickly Pear, Grass Tree (*Xanthorrœa*), and sawdust from Australian timbers, has not been found to be a commercial success, though the latter have a potential value if other products, including fibre and pulp, be exploited as well.

DURATION OF COAL SUPPLY.

From these and similar investigations, it is clear that Australia's potential wealth in regard to liquid fuel supplies lies in her coal resources.

At the present time, the annual production of coal in New South Wales is just upwards of 10 million tons, and could easily be made much greater. By the year 1945 the output should be in the vicinity of 20 million tons, at which rate the State's actual coal reserves, less 20 per cent., of approximately 16,000 million tons, would last for 800 years. If the whole of the motor spirit were extracted from this coal, at the rate of two gallons per ton, it would yield about 40 million gallons annually, which is something less than Australia's importations at the present time.

If we estimate an annual coal output of 40 million tons in New South Wales, the actual reserves, less 20 per cent., would last 400 years, and a full extraction of motor spirit as a by-product would then give 80 million gallons a year, an amount which very soon will be required annually to satisfy Australia's demands.

The total actual coal reserves in Australia, less 20 per cent., are estimated at approximately 27,660 million tons, which, at a two gallons per ton yield, would give 55,320 million gallons of motor fuel. With a prospective coal output for Australia of, say, 50 million tons annually, the supply would last about 550 years, and, with a full ex-

traction of motor fuel as a by-product, the annual yield would be 100 million gallons, still not enough for Australia's future requirements.

The position would, of course, be helped in all the foregoing cases, by the yield of some portion of the 5000 million gallons of shale oil of New South Wales and Tasmania.

AUSTRALIA HOLDS THE ASSETS.

In arriving at the total possible annual production of motor fuel from coal, no calculation has been included to show what the result would be if the whole of the possible coal reserves of Australia were exploited. So far as New South Wales is concerned, if the additional possible reserves of something like 100,000 million tons, less 20% which may be lost in winning, or, say, 80,000 million tons be included, then the previously stated quantities both of coal and oil may be increased by the addition of five times the original amounts quoted, so that 16,000 million becomes 96,000 million tons of coal, and the 32,000 million gallons of motor oil becomes 192,000 million gallons.

The data upon which these larger estimates of quantities have been made are so scanty and imperfect, and actual future production and requirements so uncertain, that at best it is only possible to form some imperfect judgment in regard to the future position. Five points, however, which have a definite bearing on the whole question stand out conspicuously. These are:—

(1) That under present methods of treatment the amount of coal being mined annually is insufficient to provide all the motor fuel required in Australia for the same period.

(2) That of the coal being mined only a small portion is being used for the extraction of oil, and this is only recovered as a by-product.

(3) That there seems little prospect in the near future of the annual production of coal, even with a full extraction of motor fuel under present methods, being sufficient to supply the necessary oil requirements of Australia.

(4) That it is imperative the most intense research should be undertaken to devise, on commercial lines, some method of treatment of coal by which a very much higher percentage of liquid fuel may be extracted or manufactured from this commodity than is obtained by present-day methods, or that some other process such as that of combustion of finely divided particles, may be perfected by which the power may be obtained direct from coal without converting it into oil.

(5) That in its actual, probable, and possible coal reserves Australia holds an enormously valuable asset.

The problem which remains for solution is one for Commonwealth consideration, and calls for scientific and technical research, the latter to include the commercial aspect of the position, both present and future, and particularly on the lines of cheapening and increasing production. Some economic method should, if at all possible, be devised to secure the recovery of the by-products before the coal is finally consumed, but it is abundantly clear that no scheme will be accepted unless it is sound financially, and this condition can be reached quickest, and the wastage arrested, by intense research.